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Modelling Economic Growth Function in Nigeria: An ARDL Approach

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Abstract

The objectives of the study were to identify the significant variables that underlie economic growth in Nigeria, ascertain the stability of the economic growth model in Nigeria over the sample period, and examine the forecasting performance of the linear dynamic model. This study applies a linear dynamic model based on Pesaran *et al.* (2001) *multivariate autoregressive distributed lag* (ARDL) modelling technique to analyze the short-run and long-run dynamics of economic growth in Nigeria over the sample period between 1986 and 2013 using quarterly data. The empirical results show that economic growth in Nigeria finds explanation in adaptive expectations. The main determining variables of economic growth in Nigeria in the short-run and long-run are expected economic growth, population and trade openness. To achieve sustainable economic growth, it is suggested that government policies directed at improving the performance of the economy should largely consider the short-run and long-run behaviour of these variables and the policies should be pursued with high degree of transparency.

Keywords: Adaptive expectation, ARDL, Co-integration, Dynamic model, First difference, Gross capital, Growth, NEEDS, Openness, Parsimonious model.

Contents

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1. Introduction

Nigeria, like any other nation, has a key policy objective of promoting a sustainable economic growth process that could improve the living standard of the people. Nigerian is recognized globally as a country with great potentials required for achieving this broad objective of sustainable economic growth. However available statistics indicate that the country has been struggling to grow (Omoke, 2010). Given the limited resources available to support development and reforms, it is not possible to tackle all possible constraints and therefore the country as a matter of necessity must prioritize. Understanding the determining variables of economic growth in Nigeria is prerequisite to identifying critical areas that need reforms. This is useful in order to direct the available resources to the most binding determining factors.

Previous efforts at planning and economic reforms such as the Structural Adjustment Programme (SAP) (1986) the National Economic Empowerment Development Strategy (NEEDS) (2003-2007) and the United Nations (UN)-sponsored National Millennium Goals for Nigeria (NMGN) (2000-2015), appear not to have accelerated the pace of economic growth to the desired threshold. This is evidenced in the adverse inflationary trend, undulating foreign exchange rates, the fall and rise of gross domestic product, unfavourable balance of payments as well as increasing unemployment rates. One reason adduced for the failure of these policy measures is the relatively weak scientific effort at explaining the dynamics of economic growth in Nigeria. As a result, policy making has relied upon macroeconomic forecasts that are not anchored on scientific models that track major economic indices (Adenikinju *et al.*, 2009).

The application of economic models in explaining the dynamics of economic growth will enable economic decision makers to exercise their judgmental analyses in a much more structured and quantified manner and to develop a more adequate understanding of macroeconomic time line. This study attempted to do this by identifying and estimating a linear dynamic model based on Pesaran *et al.* (2001) *multivariate autoregressive distributed lag* **(**ARDL) approach.

2. Theoretical Framework and ARDL Specification

The starting point of conventional economic growth theorization is the neoclassical model developed by Solow (1956) and Swan (1956) which involved a series of equations showing the relationship between labour-time, capital goods, output, and investment. This model was the first attempt to model long-run growth analytically. This model assumes that countries use their resources efficiently and that there are constant returns to scale, diminishing marginal productivity of capital, exogenously determined technical progress and substitutability between capital and labour. According to this view, the role of technological change is very important. The role of technological progress as a key driver of long-run economic growth proposed by Solow-Swan has been put to scrutiny by some economists, who accept constant and increasing returns to capital (Romer, 1990; Grossman and Helpman, 1991). Unsatisfied with Solow-Swan explanation, they worked to "endogenize" technology.

Some studies (Azege, 2004; Adebiyi, 2006; Bello and Adeniyi, 2010; Ighodaro and Oriakhi, 2010; Omoke, 2010; Adediran, 2012; Alani and Isola, 2012) have investigated the factors underlying economic growth. Using differing conceptual and methodological viewpoints, these studies have placed emphasis on different sets of explanatory parameters and offered various insights to the sources of economic growth. A major issue with growth modeling is the determination of the variables to include in the analysis which has resulted to well over ninety (90) different variables have being proposed as potential growth determinants (Petrakos *et al.*, 2007; Ristanović, 2010) each of which has some *ex ante* plausibility. This issue results because of the open-endedness of growth theories whereby the validity of one causal theory does not imply the falsity of another.

To deal with the issue of open-endedness, some researchers such as Levine and Renelt (1992) have proposed ways to deal with the robustness of variables in growth regressions by identifying a set of potential control variables for inclusion. Inclusion of a variable in the final choice requires that its associated coefficient proves to be robust with respect to the inclusion of other variables. A coefficient is robust if the sign of its OLS stays constant across a set of regressions representing different possible combinations of other variables. The bulk of modern empirical work on growth has focused on growth regressions of the type pioneered by Barro (1991). A generic form for growth regression is:

$$g_i = X_i\gamma + Z_i\pi + \varepsilon_i \qquad (1)$$

Where g_i is real *per capita* growth in economy *i* over a given period of time. X_i represents variables whose presence is suggested by Solow's growth model: a constant, initial income and a set of country-specific savings and population growth controls. The Solow's model is often treated as a baseline from which to build up more elaborate growth models, hence these variables tend to be common across studies. Z_i, in contrast, consists of variables chosen to capture additional growth determinants that a researcher believes are important and so generally differ across analysis.

Starting from the key macroeconomic relation, with an aim to considering the impact that relevant economic variables have on economic growth (proxied by GDP), Equation (1) is augmented by the influence of exchange rate (EXCRT), financial deepening (FIND), foreign direct investment (FDI), government expenditure (GOVEXP), gross capital formation (GCF), human capital (HCAP), inflation (INFN), interest rate (INTR), oil price (OILP), population growth (POP) and trade openness (TOPEN).

$$GDP_t = EXCRT_t + FDI_t + FIND_t + GOVEXP_t + GCF_t + HCAP_t + INF_t + INTR_t + OILP_t + TOPEN_t + POP_t + u_t \qquad (2)$$

The autoregressive distributed lag (ARDL) model deals with single equation modelling and was introduced by Pesaran *et al.* (2001). The autoregressive distributed lag (ARDL) approach is a co-integration technique for determining long-run and short-run relationships among variables under study simultaneously. Following Pesaran *et al.* (2001) the ARDL representation of Equation (2) is formulated and specified as follows:

$$\Delta RGDP_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1i}\Delta RGDP_{t-i} + \sum_{i=0}^{n}\alpha_{2i}\Delta EXCRT_{t-i} + \sum_{i=0}^{n}\alpha_{3i}\Delta FDI_{t-i} + \sum_{i=0}^{n}\alpha_{4i}\Delta FIND_{t-i} + \sum_{i=0}^{n}\alpha_{5i}\Delta GOVEXP_{t-i}$$
$$+\sum_{i=0}^{n}\alpha_{6i}\Delta GCF_{t-i} + \sum_{i=0}^{k}\alpha_{7i}\Delta HCAP_{t-i} + \sum_{i=0}^{n}\alpha_{8i}\Delta INFN_{t-i} + \sum_{i=0}^{n}\alpha_{9i}\Delta INTRT_{t-i} + \sum_{i=0}^{n}\alpha_{10i}\Delta OILP_{t-i}$$
$$+\sum_{i=0}^{n}\alpha_{11i}\Delta TOPEN_{t-i} + \sum_{i=0}^{n}\alpha_{12i}\Delta POP_{t-i} + \beta_1 GDP_{t-1} + \beta_2 EXRT_{t-1} + \beta_3 FIND_{t-1} + \beta_4 FODI_{t-1}$$
$$+\beta_5 GEXP_{t-1} + \beta_6 GCF_{t-1} + \beta_7 HCAP_{t-1} + \beta_8 INF_{t-1} + \beta_9 INTR_{t-1} + \beta_{10} OILP_{t-1} + \beta_{11} POP_{t-1}$$
$$+\beta_{12} TOPEN_{t-1} + \varepsilon_t \qquad (3)$$

where: RGDP = Real gross domestic product, EXRT = Exchange rate, FIND = Financial deepening,
FODI = Foreign direct investment, GOVEXP = Government expenditure,
GCF = Gross capital formation, HCAP = Human capital, INFN = Inflation, INTRT = Interest rate,
OILP = Oil price, POP = Population, TOPEN = Trade openness
Δ denotes the first difference operator, α_0 is the drift component, ε_t and is the residual.

The left-hand side is the economic growth proxied by the gross domestic product (GDP). The expressions with the summation sign $(\alpha_1 - \alpha_{12})$ on the right-hand side represent the short-run dynamics of the model. The first until twelve expressions $(\beta_1 - \beta_{12})$ on the right-hand side correspond to the long-run relationship of the model.

Therefore, *apriori* expectations of the coefficients are:

$$\alpha_1, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7, \alpha_{10}, \alpha_{11}, \alpha_{12} > 0., \alpha_2, \alpha_8, \alpha_9 < 0.$$

3. Empirical Literature on the Determinants of Economic Growth

Economic growth has long been considered an important goal of economic policy. Economic growth is most frequently expressed in terms of increase in gross domestic product (GDP), a measure of the economy's total output of goods and services. The issue of economic growth has received considerable attention from scholars. Despite this growth in research efforts, the choice of a modelling framework has remained inconclusive both at the theoretical and empirical levels in Nigeria. A literature survey on the relationship between the selected variables and economic growth in Nigeria has been outlined in this session (see Table 1).

Table-1. Determinants of Economic Growth: Literature Survey

Variable	Study	Sample Period	Country	Estimation Technique	Main Result
Exchange Rate	Anthony *et al.* (2012).	1975-2008	Nigeria	OLS technique	A long run relationship
	Dada and Oyeranti (2012).	1970-2009	Nigeria	Simultaneous equations model	No strong relationship
	Shehu and Youtang (2012).	1970-2009	Nigeria		Significant effects
Financial Deepening	Abur *et al.* (2013).	1990-2011	Nigeria	Co-integration and causality	Positive impact
	Azege (2004).		Nigeria		Moderate positive
	Nzotta and Okereke (2009).	1986-2007	Nigeria	2SLS	No impact
Foreign Direct Investment	Akinlo (2004).	1970-2001	Nigeria	ECM	Not significant
	Ayanwale (2007).	1970-2002	Nigeria	2SLS	Not significant
	Bello and Adeniyi (2010).	1970-2006	Nigeria	ARDL	No long run relationship
	Egwakhide (2012).	1980-2009	Nigeria	VECM	Lag effect
Government Expenditure	Abu and Abdullahi (2010).		Nigeria	Disaggregated analysis	Mixed
	Ighodaro and Oriakhi (2010).	1960-2007	Nigeria	Cointegration test and granger causality test	Negative impact
	Okoro (2013).		Nigeria	OLS	Long run Positive impact
Gross Capital Formation	Adekunle and Aderemi (2012).		Nigeria		Negative relationship
	Ejiogu *et al.* (2013).	1981-2011	Nigeria	OLS technique	No causality
	Ugwuegbe and Uruakpa (2013).		Nigeria	OLS technique	Positive and significant impact
	Alani and Isola (2012).		Nigeria	Growth account model	Significant relationship
Human Capital development	Anaduaka and Eigbiremolen (2014).	1999-2012	Nigeria	Augmented Solow model	Positive impact
	Ismail *et al.* (2010).	1970-2008	Nigeria	VECM	Significant impact
Inflation	Aminu and Anono (2012).	1970-2010	Nigeria	Granger causality test	GDP causes inflation
	Bassey and Onwioduokit (2011).	1970- 2006	Nigeria	OLS	Negative & insignificant

					relationship
	Omoke (2010).	1970-2005	Nigeria	Granger causality test	No co-integrating relationship
Interest Rate	Chete (2006).		Nigeria		Long run relationship
	Obamuyi (2009).	1970-2006	Nigeria	ECM	Significant effect
	Obansa *et al.* (2013).	1970-2010	Nigeria	VAR technique	Positive relationship
Oil Price	Odularu (2007).	1970-2005	Nigeria	OLS	No significant effect
	Olomola and Adejumo (2006).	1970-2003	Nigeria	Regression analysis	No significant effect
	Oriakhi and Iyoha (2013).	1970-2010	Nigeria	VAR	Positive impact
Population	Adediran (2012).	1981- 2007	Nigeria	Trend analysis	Positive impact
	Onwuka (2005).	1980-2003	Nigeria		Negative impact
Trade Openness	Adebiyi (2006).		Nigeria	VAR	Positive effect
	Seetanah *et al.* (2012).	1990-2009	Selected African countries	Panel Vector Autoregressive model (PVAR)	Positive effect

Source: Authors' Computations

From the array of empirical literature review, we found that there is no general consensus between economic growth and each of the various macroeconomic determinants. We also found that there have been few dynamic models estimated on the basis of quarterly data in explaining economic growth dynamics in Nigeria.

4. Pre-estimation Analysis

Before estimation, the graphs of the time series under study are plotted, descriptive statistics are displayed, unit root test for the variables are performed, and co-integration analysis is done on the variables. The figures below show the line graphs of the historical performance of the variables used in this study.

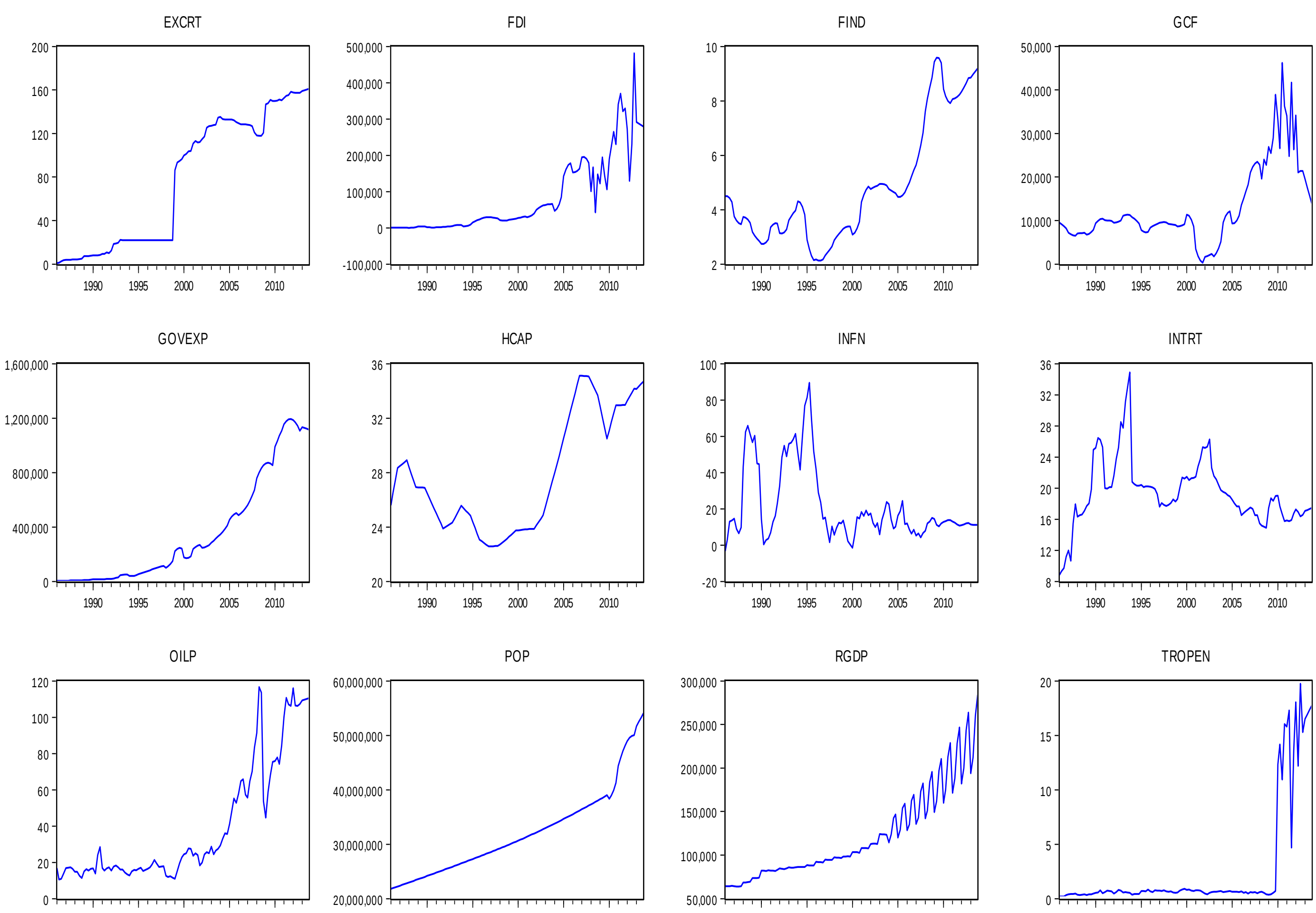

Figure-1. Variables at Levels

Source: Authors' Computations

Figure 1 shows the multiple graphs of the series at their level form

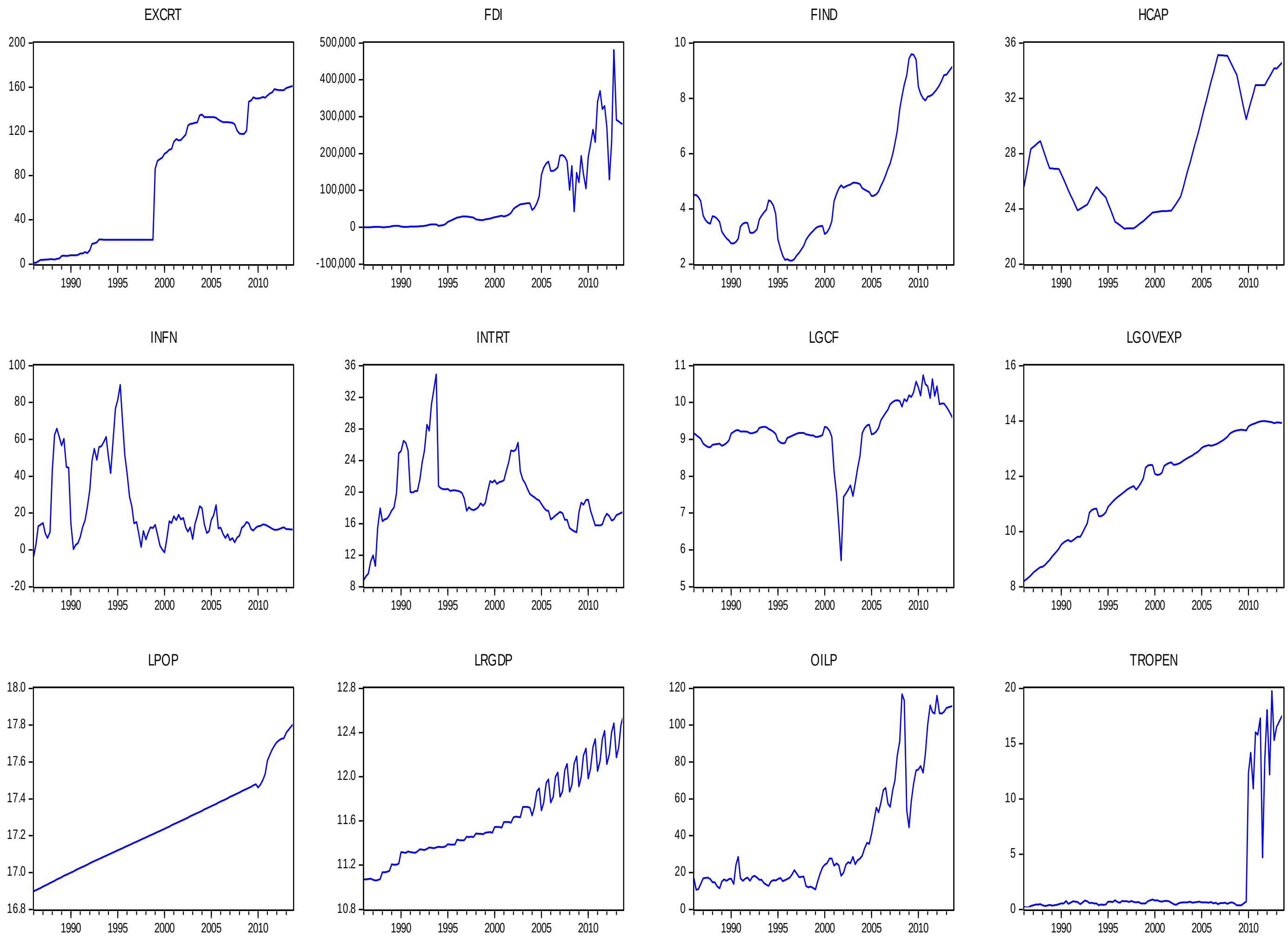

Figure-2. Logarithm of Variables

Source: Authors' Computations

The graphs show that there is little evidence to suspect the presence of structural break or outlier in the twelve variables but the graphs of logarithmic series display a more stable variance than the changes in the original series.

4.1. Descriptive Statistics

The descriptive statistics of the transformed variables were also conducted. Table 2 below provides a full descriptive statistics of the macroeconomic variables used for the research work.

Table-2. Descriptive Statistics of Variables in Nigeria (1986-2013)

Returns	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Observations
EXCRT	76.87	98.10	60.62	-0.003	1.22	14.75 (0.00)	112
FDI	81516.29	28619.66	103537.6	1.47	4.56	51.93 (0.00)	112
FIND	4.83	4.28	2.19	0.90	2.49	16.35 (0.00)	112
HCAP	27.77	26.62	4.22	0.46	1.70	11.83 (0.00)	112
INFN	21.61	13.00	20.54	1.44	4.02	43.71 (0.00)	112
INTRT	19.34	18.64	4.28	0.74	5.07	30.21 (0.00)	112
LGCF	9.22	9.18	0.79	-1.22	6.57	87.12 (0.00)	112
LGGOVEXP	11.74	12.21	1.77	-0.45	1.96	8.85 (0.00)	112
LPOP	17.26	17.24	0.23	0.52	2.60	5.82 (0.00)	112
LRGDP	11.63	11.52	0.38	0.56	2.36	7.69 (0.00)	112
OILP	39.13	23.15	33.02	1.20	2.99	26.84 (0.00)	112
TROPEN	2.62	0.62	5.22	2.24	6.27	144.12 (0.00)	112

Source: Authors' Computations

The table shows the mean, standard deviation, skewness, kurtosis, and normality of the variables. The mean of the variables shows their average values from 1986 to 2013. The standard deviation shows that there is some dispersion in all the variables. Lastly, skewness, kurtosis and Jarque-Bera (JB) statistics showed that all the variables are normally distributed at 1% level of significance.

The absence of outliers, especially real gross domestic product (LRGDP), indicates that we can model economic growth in Nigeria without having extreme large or small values that deviate from the historical real gross domestic product (RGDP) series. The descriptive statistics show that the variables have some variations and using them in the models will require identifying their stationarity properties.

4.2. Unit Root Tests for the Variables

The use of ARDL models does not impose pre-testing of variables for unit root problems. However, unit root tests are conducted in this study to find out if there are mixtures in the order of integration of our variables. The order of integration of the time series was investigated by applying the Augmented Dickey and Fuller (1979) test. The Augmented Dickey-Fuller (ADF) unit root test results for the time series variables are presented in Table 3 below.

Table-3. Unit Root Test Results

Variable	ADF Test Statistic	95% Critical ADF Value	Order of Integration	Remark
D(EXCRT)	-9.49*	-2.888	*I* (1)	Stationary
D(FDI)	-11.04*	-2.888	*I* (1)	Stationary
D(FIND)	-4.93*	-2.888	*I* (1)	Stationary
D(HCAP)	-3.51*	-2.888	*I* (1)	Stationary
D(INFN)	-7.14*	-2.888	*I* (1)	Stationary
D(INTRT)	-9.79*	-2.888	*I* (1)	Stationary
D(LGCF)	-9.92*	-2.888	*I* (1)	Stationary
D(LGOVEXP)	-6.73*	-2.888	*I* (1)	Stationary
D(LPOP)	-5.02*	-2.888	*I* (1)	Stationary
D(LRGDP)	-31.16*	-2.888	*I* (1)	Stationary
D(OILP)	-9.94*	-2.888	*I* (1)	Stationary
D(TOPEN)	-11.08*	-2.888	*I* (1)	Stationary

Source: Authors' Computations
Note: * = 1percent significance; ** = 5 percent significance.

In the results shown in Table 3 above, the ADF test statistic for each of the variables are greater than the respective critical values. Thus, we accept the hypothesis of unit roots in each of the time series. In our final evaluation all the variables became stationary after first difference. Hence, they are integrated of order *I* (1). Once all the series are non-stationary in the level, one can estimate an econometric model only if they are co-integrated. Thus co-integration tests can be applied for all variables.

4.3. Co-Integration Test

The two popular co-integration tests in applied time series modelling are the Engel and Granger (1987) co-integration test and the Johansen and Juselius (1990) co-integration test. The Engel & Granger co-integration test is adopted in cases of single equation models while the Johansen and Juselius co-integration test is used for system equation models. The autoregressive distributed lag (ARDL) model is based on single equation modelling (Pesaran *et al.*, 2001). This therefore implies that Engel & Granger co-integration method is used in the co-integration test. Using the Engel and Granger two-stage technique, the co-integration test result for the research model is presented in Table 4 below.

Table-4. Engel & Granger Residual Based Co-Integration Test

SERIES	ADF	5% CRITICAL VALUE	ORDER OF INTEGRATION	REMARK
RESIDUAL	-5.88	-2.888	**I (0)**	**Co-integrated**

Source: Authors' Computations.

The results in Table 3 show that there is co-integration among economic growth proxied by real gross domestic product (RGDP), exchange rate (EXCRT), financial deepening (FIND), foreign direct investment (FDI), government expenditure (GOVEXP), gross capital formation (GCF), human capital formation (HCAP), inflation (INF), interest rate (INTRT), oil price (OILP), trade openness (TOPEN), and population growth (POP). Since the ADF test value for the residual is greater than the critical value, it is said to be stationary. Thus, the time series are co-integrated, implying that a long-run stable relationship exists among the variables used in this study. This means that any short-run deviation in their relationships would return to equilibrium in the long-run.

5. Estimation, Diagnostics and Interpretation of ARDL Model

The autoregressive distributed lag (ARDL) is a technique that allows us to simultaneously estimate the short-run and long-run coefficients of our model. In order to examine the long-run and short-run relationships between economic growth and its focus variables, the parametized version of ARDL model (Pesaran *et al.*, 2001) with lag four is estimated. The diagnostic tests like Breusch-Godfrey serial correlation LM test, the ARCH test for heteroscedasticity, Jarque-Bera test for normality of the residual term, are performed on the model. Finally, the model is used to forecast inflation in Nigeria over the sample period and the forecast performance evaluated.

5.1. The Parsimonious Autoregressive Distributed Lag (ARDL) Estimates

Following Hendry (1995) general to specific modelling approach, exchange rate, foreign direct investment and price of crude oil were deleted from the parametized model because of their insignificant coefficients to arrive at the parsimonious model. The parsimonious model equation can be formed as:

$$
\begin{aligned}
&\Delta(LRGDP)_t = -24.4 + 0.30\Delta LRGDP_{t-1} + 0.73\Delta LRGDP_{t-4} - 0.03\Delta FIND_t - 0.02\Delta HCAP_{t-4} - 0.001\Delta INTRT_{t-1} \\
&\qquad (-4.5)\quad (4.5) \qquad\qquad (10.6) \qquad\qquad (-1.8) \qquad\quad (-2.0) \qquad\qquad (-0.95) \\
&\qquad -0.0003\Delta INTRT_{t-2} - 0.001\Delta INTRT_{t-3} - 0.0009\Delta INTRT_{t-4} + 0.0004 LGCF_{t-1} - 0.02 LGCF_{t-2} \\
&\qquad (-0.17) \qquad\qquad (-0.8) \qquad\quad (0.5) \qquad\qquad (0.04) \qquad\quad (-1.44) \\
&\qquad +0.07\Delta GOVEXP_{t-1} + 0.03\Delta GOVEXP_{t-2} + 0.08\Delta GOVEXP_{t-3} + 2.4\Delta LPOP_t + 1.27\Delta LPOP_{t-1} \\
&\qquad (1.5) \qquad\qquad (0.55) \qquad\qquad (1.6) \qquad\qquad (2.8) \qquad\quad (2.1) \\
&\qquad +0.32\Delta LPOP_{t-2} + 0.03\Delta TOPEN_{t-1} + 0.02\Delta TOPEN_{t-2} + 0.02\Delta TOPEN_{t-3} + 0.01\Delta TOPEN_{t-4} \\
&\qquad (0.6) \qquad\qquad (4.2) \qquad\qquad (3.9) \qquad\qquad (3.8) \qquad\qquad (2.7) \\
&\qquad -0.62 LRGDP_{t-1} + 1.50^{E-07} FDI_{t-1} + INFN_{t-1} + 0.0048 INTRT_{t-1} + 0.03 LGCF_{t-1} - 0.09 LGOEXP_{t-1} \\
&\qquad (-5.1) \qquad\qquad (1.6) \qquad\quad (-1.7) \qquad\quad (2.7) \qquad\qquad (3.5) \qquad (-3.8) \\
&\qquad +1.87 LPOP_{t-1} - 0.03 TOPEN_{t-1} \\
&\qquad (4.7) \qquad\qquad (4.3)
\end{aligned} \qquad 4
$$

5.2. Estimated ARDL (4, 0, 4, 4, 2, 3, 2, 4) Diagnostics

After the estimation of the empirical ARDL (4, 0, 4, 4, 2, 3, 2, 4) model, there are a variety of diagnostic and stability tests which enhance the credibility of the model. The model was tested for autocorrelation (Breusch-Godfrey serial correlation LM test), for heteroskedasticity (White test), for normality (Jarque-Bera test), and for specification error/omitted variables (Ramsey RESET test). The results of the respective diagnostic test are presented in Table 5.

Table-5. ARDL (4, 0, 4, 4, 2, 3, 2, 4) Diagnostic Tests

TEST	F-STATISTIC	P-VALUE
Serial Correlation: Breusch-Godfrey serial correlation LM test	5.75	0.00
Autoregressive conditional Heteroskedasticity: White test.	0.31	0.59
Normality: Jarque-Bera test.	441.24	0.00
Specification Error: Ramsey RESET test	16.64	0.00

Source: Authors' Computations

From the results reported in Table 5 the diagnostics indicate that the residuals are serially uncorrelated, homoskedastic, normally distributed based on Breusch-Godfrey serial correlation LM test, ARCH LM test, and Jarque-Bera test respectively. This means that the model is valid and can be used for policy recommendations without re-specification.

The model is well specified on the basis of the Ramsey RESET test. The existence of a stable and predictable relationship is considered a necessary condition for the formulation of economic policy strategies. Instability of a model could result from inadequate modelling of the short-run dynamics characterizing departures from the long-run relationship. Hence, it is important to include the short-run dynamics for constancy of long-run parameters. In view of this we apply the CUSUM-of-squares (CUSUM-SQ) test, which Brown *et al.* (1975) developed. If the plot of CUSUM-SQ statistic stays within 5% significance level, then the estimated coefficients are said to be stable. A graphical presentation of this test for our ARDL model is provided in Figure 3 below.

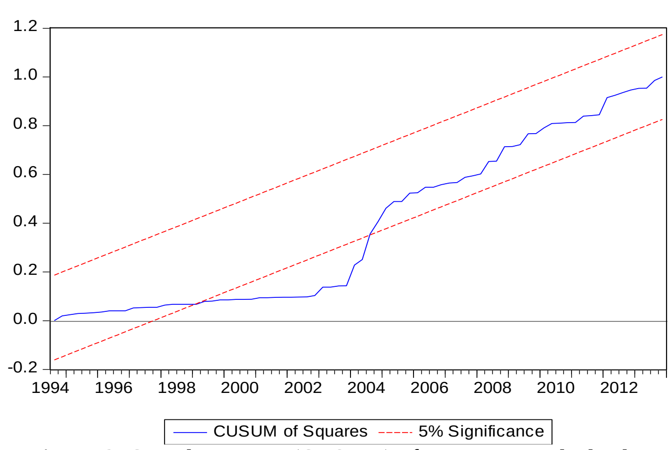

Figure-3. Cumulative sum (CUSUM) of recursive residuals plot
Source: Authors' Computations

The result in Figure 3 clearly indicates that the model has been relatively stable apart from between 1999 and 2004. We are therefore safe to conclude that ARDL economic growth function is stable and economic growth can be used as a target variable.

5.3. Forecast and Forecast Evaluation for ARDL (4, 0, 4, 4, 2, 3, 2, 4) Model

In the next step, forecast of Nigerian inflation series using ARDL (4, 0, 4, 4, 2, 3, 2, 4) model is conducted. Smaller values of the coefficients are preferred. The duration of the forecasts is from 1986Q1 to 2013Q4. The forecasts are plotted in Figure 4.

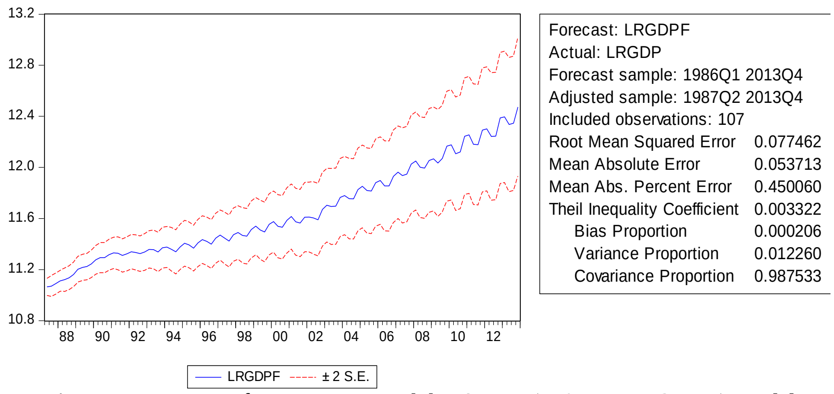

Figure-4. Forecast of economic growth by ARDL (4, 0, 4, 4, 2, 3, 2, 4) Model
Source: Authors' Computations

In Figure 4 some forecasting measurements such as root mean squared error (RMSE), mean absolute error (MAE), and Theil inequality coefficient are shown. Their coefficient values from ARDL (4, 0, 4, 4, 2, 3, 2, 4) model are tabulated in Table 6. The results show that the model is relevant for forecasting economic growth in.

Table-6. Forecasting Performance of ARDL (4, 0, 4, 4, 2, 3, 2, 4)

Forecast Performance	Coefficient
RMSE	0.08
MAE	0.05
Theil Inequality Coeff.	0.00

Source: Authors' Computations

From Table 6 we can conclude that ARDL (4, 0, 4, 4, 2, 3, 2, 4) model performs very well. In other words, ARDL (4, 0, 4, 4, 2, 3, 2, 4) model can be applied in explaining economic growth dynamics in Nigeria over the sample period.

6. Discussion of Findings, Conclusion and Recommendations

The study empirically examines the economic dynamics in Nigeria using the autoregressive distributed lag (ARDL) framework using quarterly time series data that cover the period from the first quarter of 1986 to the fourth quarter of 2013 (1986Q1-2013Q4). The data were sourced from the publications of the Central bank of Nigeria (CBN) and the National Bureau of Statistics (NBS).

By considering recent empirical studies in the context of economic growth, an empirical multivariate autoregressive distributed-lag model is constructed which emphasizes the effect of eleven (11) variables on economic growth. The study estimates a parsimonious ARDL model. Diagnostic tests for serial correlation (Breusch-Godfrey serial correlation LM test), heteroskedasticity (ARCH test), normality (Jarque-Bera test), specification error (Ramsey RESET test), and CUSUM-of-squares test were performed on the estimated model. In-sample forecast of economic growth dynamics using the estimated ARDL (4, 0, 4, 4, 2, 3, 2, 4) model was conducted. Some forecasting measurements such as root mean squared error (RMSE), mean absolute error (MAE), mean absolute percent error (MAPE), and Theil inequality coefficient (TIC) were computed. The empirical results from the parsimonious ARDL (4, 0, 4, 4, 2, 3, 2, 4) model is reported in Table 7 below.

Table-7. The Parsimonious ARDL (4, 0, 4, 4, 2, 3, 2, 4) Result

Dependent Variable: D(LRGDP)		
Short-run Dynamics		
Independent Variable	**Coefficient**	**Probability**
Constant	-24.37 (-4.47)*	0.0000
Independent Variables		
First difference log of real gross domestic product with one-period lag	0.30 (4.53)*	0.0000
First difference log of real gross domestic product with four-period lag	0.73 (10.59)*	0.0000
First difference of financial deepening	-0.03 (-1.78)***	0.0784
First difference log of real gross domestic product with four-period lag	-0.02 (-2.02)**	0.0469
First difference log of population	2.4 (2.75)*	0.0073
First difference log of population with one-period lag	1.27 (2.06)**	0.0431
First difference of trade openness with one-period lag	0.03 (4.19)*	0.0001
First difference of trade openness with two-period lag	0.02 (3.93)*	0.0002
First difference of trade openness with three-period lag	0.02 (3.76)*	0.0003
First difference of trade openness with four-period lag	0.01 (2.75)*	0.0075

Long-Run Dynamics		
Log of real gross domestic product	-0.6 (-5.12)*	0.0000
Inflation	-0.0004 (-1.77)**	0.0804
Interest rate	0.004 (2.68)*	0.0090
Log of gross capital formation	0.03 (3.53)*	0.0007
Log of government expenditure	-0.09 (-3.77)*	0.0003
Log of population	1.87 (4.66)*	0.0000
Trade openness	-0.03 (-4.26)*	0.0001
R-squared	0.933064	
Adjusted R-squared	0.909036	
F-statistic	38.83198	
Prob(F-statistic)	0.000000	

Source: Authors' Computations
T-statistics are in parenthesis; *, and ** imply significant at 1% and 5% confidence level respectively.

Table 7 presents the results of short-run and long-run coefficients of the estimated parsimonious model. The coefficient of determination (= 0.93) of the estimated model shows that about 93% of the variation in economic growth of Nigeria is jointly explained and accounted for by the independent variables in the estimated ARDL (4, 0, 4, 4, 2, 3, 2, 4) model. This when adjusted for degree of freedom based on the adjusted coefficient of determination (Adjusted R-bar squared = 0.91) shows that the ARDL (4, 0, 4, 4, 2, 3, 2, 4) model has about 91% explanatory power with respect to variations in economic growth of Nigeria. This implies that the ARDL model has a satisfactory goodness of fit. The F-test which is used to determine the overall statistical significance of a regression model shows that the overall regression is statistically significant at 1% level. This therefore means that the overall ARDL (4, 0, 4, 4, 2, 3, 2, 4) model (that is, the short and long run coefficients of the entire explanatory variables as they relate to the dependent variable) is statistically different from zero.

The findings were discussed with the research objectives. As shown in Table 7 in the short run, the first quarter lag and fourth quarter lag of gross domestic product are statistically significant at 1% with positive impact. This means that the economic growth function follows the adaptive expectation theory. The current level of financial deepening has a negative impact and significant at 10%. This result is not consistent with extant literature (Azege, 2004; Nzotta and Okereke, 2009; Abur *et al.*, 2013). The fourth quarter lag of human capital has a negative and significant impact at 5%. This result is not consistent with extant literature (Ismail *et al.*, 2010; Anaduaka and Eigbiremolen, 2014). The current level of population has a positive impact and significant at 1% and the first quarter lag of population has a positive impact and significant at 5%. These results are consistent with Adediran (2012) but not consistent with Onwuka (2005). The first quarter, second quarter, third quarter and the fourth quarter lags of trade openness have positive impacts and significant at 1%. These results are consistent with Adebiyi (2006) and Seetanah *et al.* (2012).

In the long-run, expected gross domestic product has a negative impact on economic growth at 1%. This also means that the economic growth function follows the adaptive expectation theory. Government expenditure has a negative impact on economic growth at 1%. This result is consistent with the results of Ighodaro and Oriakhi (2010) and but not consistent with the result of Okoro (2013). Inflation has a negative impact on economic growth at 10%. This result is consistent with the results of Bassey and Onwioduokit (2011) but not consistent with the result of Omoke (2010). Trade openness has a negative impact on economic growth at 1% population on economic growth at 1%. This is not consistent with the results of Adebiyi (2006) and Seetanah *et al.* (2012). Interest rate has a positive impact on economic growth at 1%. This result is consistent with the results of Chete (2006); Obamuyi (2009) and Obansa *et al.* (2013). Gross capital formation has a positive impact on economic growth at 1%. This result is consistent with the result Ugwuegbe and Uruakpa (2013) but not consistent with the result of Adekunle and Aderemi (2012). Population growth has a positive impact on economic growth at 1%. This result is consistent with the result Adediran (2012) but not consistent with Onwuka (2005).

This study has empirically attempted to investigate the relationship between economic growth and the selected explanatory variables by employing the ARDL modelling technique. The study found that ARDL (4, 0, 4, 4, 2, 3, 2, 4) model can provide information both on the short-run and on the long-run behaviour of economic growth in Nigeria. The empirical results showed that the main determining variables of economic growth in Nigeria in the short-run and long-run are expected economic growth, population and trade openness.

To achieve sustainable economic growth, it is recommended that government policies directed at improving the performance of the economy should largely consider the short-run and long-run behaviour of these variables and the policies should be pursued with high degree of transparency.

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